Estimating Quantities of Solvent-Containing Rags That Can be Disposed in a MSW Landfill

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1.0 Preface

This deliverable was initially prepared in response to a quick response task. While it represents a "free standing" analysis, it is ultimately intended to be inserted into the technical background document being prepared concurrently for this work assignment. The format, therefore, is presented as a chapter to that report.

1.1 Introduction

To better understand the potential risks associated with the disposal of solvent-contaminated wipes and rags, a screening level risk assessment was conducted. The purpose of the risk screening analysis was to determine constituent-specific risks from the disposal of solvent-contaminated wipes and rags in a municipal solid waste landfill. The results of the risk screening analysis can be applied to the following questions: (1) which constituents present the most risk; and (2) using reasonable assumptions, do circumstances exist where disposables can be managed in landfills that result in negligible risk?

Disposable wipes and rags undergo a complex series of individual management steps. For example, in most cases the wipes and rags are generated and stored onsite, transferred to a larger waste container onsite, transported by truck to a landfill or transfer station, then finally disposed in a landfill. In this screening analysis, only one of the steps is considered: disposal at the landfill. As such, this analysis assumes that the potential risks associated with the landfill management step are significantly higher than any other management step.

The risk analysis first considers the toxicity of individual components in the solvents. The disposal of rags contaminated with any one of 34 constituents that are part of the basis of the F001 to F005 hazardous waste listings (i.e., 'F-listed solvents') was considered[1]. [Other solvents, such as those that are ignitable-only or nonhazardous when spent, are not assessed; contaminants such as metals are also not assessed]. The human health effects of these compounds range from constituents with very low toxic effects to carcinogenic constituents with high toxic effects. The risk assessment considered multimedia exposure from the disposal of rags in a landfill (i.e., air releases from the landfill, and releases to ground water with subsequent exposure by ingestion and non-ingestion routes). Different climatic, receptor, and landfill size assumptions were evaluated. Various combinations of receptor and pathway assumptions resulted in varying levels

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[1] The definitions of F001 to F005 include specific compounds (e.g., acetone) and chemical classes (e.g., cresols). For this evaluation EPA selected 34 specific compounds which represent all chemicals included in the F001 to F005 listings.

of calculated risk; the scenario and pathway resulting in highest risk for each constituent was selected for further consideration. The result of this analysis was an estimate of the quantity of each compound present in solvents that may be disposed in a municipal solid waste (MSW) landfill without exceeding risk criteria[2]. For some constituents, risk criteria could be exceeded with as little as 0.01 kg/day of the constituent disposed in a single landfill, while more than 1,000 kg/day of other constituents could be disposed in a single landfill and risk criteria would not be exceeded (these numbers are taken from the third column of Table 1-3, which will be explained later). Further details regarding the risk assessment are presented in Section 1.3.1.

To put this quantity in perspective, a second question must be asked: "will this quantity be exceeded by current or projected disposal practices, and thus pose a risk?" This assessment considers the factors outlined in Table 1-1: the number of facilities likely to use the constituent in solvents, the quantity used, etc. These variables are summarized in Table 1-1. As shown in this table, there can be wide variability in the assumptions. However, these assumptions do not necessarily reflect extreme situations. For example, a situation where LQGs use large quantities of a single constituent in pure form with disposable rags, was not assessed; the incorporation of such assumptions would make many constituents appear to have large risks from landfill disposal.

Table 1-1. Factors Affecting Risk from MSW Landfill Disposal of Solvent-Containing Materials

Factor	How Addressed in Assessment
There are different types of solvents: characteristic, nonhazardous, or F-listed when spent	Only 10 percent of facilities are assumed to use F-list solvent
Not every solvent would have every F-list constituent	Each constituent was assigned a probability of 10 or 50 percent of being present in a solvent, based on usage information from site visits, etc.
The toxicity of the components in the solvent used (i.e., differing health effects)	Multimedia effects from single constituents were assessed. Constituent-specific toxic and physical properties were used. Only landfill disposal was considered.
The concentration of these components (i.e., whether present in solvent in pure form, or as mixture)	Constituents were assumed to be present as a mixture, with concentration ranges based on site visits/MSDSs
The volume of solvent used by a facility (e.g., differing quantity of solvent and rags generated by LQGs or SQGs)	Facilities were assumed to use varying quantities of rags (30 to 120 per facility), with solvent use ranging from light to moderate (4 to 40 grams per rag). A second assessment considered centrifuging down to 2 grams/rag.
The use of disposable rags (i.e., rather than reusable rags)	Only facilities using disposable rags were assessed. About 1 in 4 facilities were assumed to use disposables.

[2] Risk criteria are a hazard quotient (HQ) of 1 for noncarcinogens and a cancer risk coefficient of 10^{-6} for carcinogens. Of the 34 compounds evaluated, 28 are noncarcinogens.

Table 1-1. Factors Affecting Risk from MSW Landfill Disposal of Solvent-Containing Materials	
Factor	How Addressed in Assessment
The management scenarios employed for disposable rags (e.g., disposal by municipal or nonhazardous waste combustion rather than by landfilling)	Only facilities using MSW landfills, rather than MWCs, were considered. About 75 percent of MSW is landfilled, 25 percent combusted.

Throughout these sections, the equations will be illustrated through sample calculations for one compound, methyl ethyl ketone (MEK).

1.2 Summary of Results

Two analyses were conducted. In the first analysis, fairly median (central tendency) assumptions were used for many of the variables identified in Table 1-1 (Section 1.3 details the calculations used). In the second analysis, more conservative assumptions are used together with assumptions regarding more protective management (i.e., centrifuging) (Section 1.4, assesses assumptions regarding centrifuging). The results of these analyses are summarized in Table 1-2. Nineteen of the 34 constituents clearly fall below EPA risk criteria, while the remaining 15 constituents are marginal or above this criteria using the first analysis. Using the second analysis of centrifuging, six less constituents are of concern (i.e., 25 of 34 constituents fall below the risk criteria).

The results of these two analyses demonstrate that there are a 'core' number of constituents which will likely never exceed risk criteria even under bounding risk assumptions (e.g., high solvent loadings, high number of facilities using the compound). Other compounds always exceed risk criteria even when using less conservative or central tendency assumptions (e.g., rag is centrifuged, compound is part of a mixture in a solvent). Table 1-3 illustrates the variability in toxicity of constituents. For example, Table 1-3 shows that the disposal of 0.01 kg/day of 2-nitropropane in a single landfill results in the same risk as the disposal of 2,600 kg/d of o-xylene (these values are from the third column). This shows that 2-nitropropane is much more toxic, and that very little can be safely managed in a landfill. Based on examination of Table 1-1 in this manner, eight constituents appear to present extreme risks that may not be mitigated (i.e., less than one facility disposing in a single landfill is expected to result in excess risk). Even management options such as centrifuging may not be effective in mitigating risks from such constituents. At the other extreme, six constituents are unlikely to present risks even using more conservative parameters (i.e., more than one hundred facilities would need to dispose in a single landfill to exceed risk criteria).

Table 1-2. Summary of Risk Analysis Results: Rags in MSW Landfill		
Assumptions	Constituent Loading	Results
Highest receptor risk; 30 to 120 heavy rags used per facility	4 to 40 g/rag	10 of 23 nonhalogenated solvents exceed risk; 5 of 11 halogenated solvents exceed risk, using upper end of range (e.g., 40 g loading rather than 4 g loading).
Highest receptor risk; high quantity (500) of medium-weight rags used per facility; centrifuging used.	2 g/rag	6 of 23 nonhalogenated solvents exceed risk; 3 of 11 halogenated solvents exceed risk.

Table 1-3 presents the results of the analysis for the initial assessment (e.g., no exceptionally large quantities of solvent used by facilities; assumptions regarding input parameters are presented as footnotes to the table). The table includes five columns:

- The first column is the name of the compound evaluated. This compound is a component in a solvent. The 34 F-listed constituents are presented.

- The second column is the quantity of the constituent (in kg/d) that can be disposed in a landfill which would equal EPA's risk criteria (of HQ=1 or carcinogenic risk=10^{-6}).[3] If the constituent is disposed at a rate greater than this, then risk would increase. The calculated values in this column result from differences in toxicity benchmarks (e.g., RfDs) and environmental transport considerations, rather than differences in solvent use at individual facilities.

- The third column presents the number of facilities that are expected to result in a rate of disposal equal to the previous column. For example, in the case of methyl ethyl ketone, between 1.3 and 170 facilities (depending on the assumptions employed) are expected to dispose a total of 0.33 kg/day.

- The fourth column represents the population of facilities expected to potentially use solvents containing the specific contaminant, which would be served by a single landfill. For consistency with the other data in the table, these are expressed on a per landfill basis. This table shows that between 1.7 and 19 facilities are expected use MEK, served by a single landfill.

- The final column assesses if the constituent loading is expected to result in excess risk. ('Yes' indicates that the loading exceeds an HQ of 1; 'No' indicates loading is below this risk criteria). This assessment is made by comparing the third and

[3] The risk criteria corresponds to a cancer risk coefficient of 10^{-6}, or hazard quotient of 1, for a child receptor from multimedia exposure.

fourth columns. When the ranges in these columns overlap (e.g., for MEK), excess risk is expected under some circumstances.

The risks presented in Table 1-3 represent an approximation. The most important limitations are as follows:

- There is wide variability in each of the usage parameters considered, such as the quantity of rags and solvent used by facilities. While ranges are presented, the overall assessment (presented in the last column) is whether the extreme end of the range exceeds risk criteria.
- The additive nature of risks posed by ground water exposure are not considered. For example, if a receptor is simultaneously exposed to ground water from ingestion, and ground water from inhalation or dermal exposure, then exposures should be summed across these different pathways.
- The effects of multiple constituents are not assessed. For example, a solvent is assumed to contain only one constituent, and a facility is assumed to use only one constituent.

Table 1-3. Summary of Risk Analysis Results

Constituent	Maximum Unit Risk From RTI Report (based on 1.3 kg/d/landfill) [A]	Quantity Resulting in HQ=1 or Risk=10^{-6} (kg/d/landfill)	Number of Facilities/ Landfill Disposing This Quantity	Universe of Facilities Using Compound (/Landfill Basis)	Is There Excess Risk? (i.e., is the universe of facilities greater than the number resulting in risk?)
Nitrobenzene (F004)	HQ= 25	0.05	0.1 - 48	0.3 - 3.7	Yes
Pyridine (F005)	HQ= 120	0.01	<0.1 - 10	0.3 - 3.7	Yes
Ethyl ether (F003)	HQ= 0.3	4.3	100 - 4,000	0.3 - 3.7	No
Acetone (F003)	HQ= 0.7	1.9	5.3 - 1,700	1.7 - 19	Yes
Methanol (F003)	HQ= 0.2	6.5	23 - 30,000	1.7 - 19	No
Butanol (F003)	HQ= 0.8	1.6	47 - 1,900	1.7 - 19	No
Carbon disulfide (F005)	HQ= 2	0.65	1.5 - 600	0.3 - 3.7	Yes
Methyl ethyl ketone (F005)	HQ= 4	0.33	1.3 - 170	1.7 - 19	Yes
o-Cresol (F004)	HQ= 0.1	13	30 - 12,000	0.3 - 3.7	No
p-Cresol (F004)	HQ= 3	0.43	1 - 400	0.3 - 3.7	Yes
Methyl isobutyl ketone (F003)	HQ= 42	0.03	0.1 - 29	0.3 - 3.7	Yes

Table 1-3. Summary of Risk Analysis Results					
Constituent	Maximum Unit Risk From RTI Report (based on 1.3 kg/d/landfill) [A]	Quantity Resulting in HQ=1 or Risk=10^{-6} (kg/d/landfill)	Number of Facilities/ Landfill Disposing This Quantity	Universe of Facilities Using Compound (/Landfill Basis)	Is There Excess Risk? (i.e., is the universe of facilities greater than the number resulting in risk?)
Cyclohexanone (F003)	HQ= 0.02	65	1,900 - 75,000	1.7 - 19	No
2-Ethoxyethanol (F005)	HQ= 0.3	4.3	10 - 4,000	0.3 - 3.7	No
Tetrachloroethylene (F002)	HQ= 0.2	6.5	17 - 15,000	1.7 - 19	Yes
Isobutyl alcohol (F005)	HQ= 0.3	4.3	100 - 4,000	1.7 - 19	No
m-Cresol (F004)	HQ= 0.2	6.5	15 - 6,000	0.3 - 3.7	No
Chlorobenzene (F002)	HQ= 3.6	0.36	0.8 - 340	0.3 - 3.7	Yes
Ethyl acetate (F003)	HQ= 0.08	16	94 - 19,000	1.7 - 19	No
Trichlorofluoromethane (F002)	HQ= 0.08	16	90 - 4,700	1.7 - 19	No
Dichlorodifluoro-methane (F001)	HQ= 0.6	2.2	5 - 2,000	0.3 - 3.7	No
o-Xylene (F003)	HQ= 0.0005	2,600	6,000 - 2.4 million	1.7 - 19	No
1,2-Dichlorobenzene (F002)	HQ= 0.1	13	30 - 12,000	0.3 - 3.7	No
Ethyl benzene (F003)	HQ= 0.1	13	750 - 60,000	1.7 - 19	No
m-Xylene (F003)	HQ= 0.0005	2,600	270,000 - 11 million	1.7 - 19	No
Toluene (F005)	HQ= 0.6	2.2	5 - 3,400	1.7 - 19	Yes
1,1,2-Trichlorotrifluoro-ethane (F002)	HQ= 0.0032	406	940 - 377,000	1.7 - 19	No
1,1,1-Trichloroethane (F002)	HQ= 0.08	16	25 - 3,600	1.7 - 19	No
Xylenes (total) (F003)	HQ= 0.21	6.2	42 - 29,000	1.7 - 19	No
2-Nitropropane (C) (F005)	C.R. = 4×10^{-3}	<0.01	<0.1 - 0.3	0.3 - 3.7	Yes
Methylene chloride (C) (F002)	C.R. = 15×10^{-6}	0.09	0.1 - 45	1.7 - 19	Yes

Table 1-3. Summary of Risk Analysis Results					
Constituent	Maximum Unit Risk From RTI Report (based on 1.3 kg/d/landfill) [A]	Quantity Resulting in HQ=1 or Risk=10^{-6} (kg/d/landfill)	Number of Facilities/ Landfill Disposing This Quantity	Universe of Facilities Using Compound (/Landfill Basis)	Is There Excess Risk? (i.e., is the universe of facilities greater than the number resulting in risk?)
1,1,2-Trichloroethane (C) (F002)	C.R. = 7×10^{-6}	0.19	0.4 - 170	0.3 - 3.7	Yes
Carbon tetrachloride (C) (F001)	C.R. =2.6×10^{-6}	0.50	1.2 - 460	0.3 - 3.7	Yes
Benzene (C) (F005)	C.R. = 13×10^{-6}	0.10	0.2 - 93	0.3 - 3.7	Yes
Trichloroethylene (C) (F002)	C.R.=0.27×10^{-6}	4.8	11 - 4,500	0.3 - 3.7	No

C.R. indicates carcinogenic risk; HQ indicates hazard quotient (noncarcinogenic risk).
All constituents are noncarcinogens unless indicated by (C); (C) designates carcinogens.
Calculations for all constituents are presented in Attachment B. Sample calculations are in Appendix A.
A. Assumes 1.3 kg/day by assuming that an LQG uses (and disposes) 120 rags/day, using a Kimberly-Clark Workhorse wipe would be used (the most common wipe or rag used by industry in conjunction with solvents), and that each wipe and rag would have 10.4 grams of solvent applied, or 1 times the weight of the wipe/rag.
Data in table calculated from following factors:

- toxicity/transport considerations of individual compound;
- quantity of solvent on disposed rags (range assumed to be 0.12 to 4.8 kg/facility/day);
- percentage of facilities using disposables (23%)
- percentage of disposables managed in landfills (78%)
- percentage of compound in solvent blend (varies; see Attachment B)
- total number of generators (77,700)
- percentage using F-list solvents (11%)
- percentage using particular compound in solvent (varies; 10% or 50% depending on judgement of whether compound is common or uncommon)
- number of facilities served by a landfill (0.040% or 0.43% of total 77,700)

1.3 Methodology and Assumptions

As stated in Section 1.1, risk is the cumulative result of many factors, some of which were identified in Table 1-1. The assumptions (and uncertainty) in the above factors are discussed in detail in the following sections. Section 1.3.1 focuses on the quantity of each F-listed constituent that can be disposed in a landfill resulting in risks equal to EPA's risk criteria, while Sections 1.3.2 and 1.3.3 focus on the number of facilities that can use solvents without creating unacceptable risks.

1.3.1 *Landfill Design, Transport, and Receptor Assumptions*

Landfill Design and Control Assumptions

The risk screening analysis made several assumptions regarding disposal practices, including the following:

- Only landfill disposal is considered. Risks from storage, alternative management, etc., are not considered.

- The landfill is assumed to be unlined.

- The landfills (and generators) are distributed throughout the U.S.

- A single generator (SQG or LQG) manages their waste in a single landfill. Of course, multiple generators are expected to use a single landfill. The effect of this assumption is to obtain a "unit risk," which can be scaled appropriately depending on an estimate for the number of facilities using a single landfill.

- Assumptions regarding daily and final cover were consistent with federal regulations.

- Biodegredation of the organic constituents was considered.

Greater discussion of the assumptions and analysis is presented in the risk screening analysis report found elsewhere in the docket for this rule, "Estimating the Risk from the Disposal of Solvent-Contaminated Shop Towels and Wipes in Municipal Landfills" (EPA Report, March, 1999). The screening analysis also considered eight specific scenarios, each corresponding to a different landfill size, waste quantity, and climatic condition. These eight scenarios corresponded to the following:

- Median landfill size, high end climatic conditions, large quantity generator
- Median landfill size, median climatic conditions, large quantity generator
- Median landfill size, high end climatic conditions, small quantity generator
- Median landfill size, median climatic conditions, small quantity generator
- Small (high end) landfill size, high end climatic conditions, large quantity generator
- Small (high end) landfill size, median climatic conditions, large quantity generator
- Small (high end) landfill size, high end climatic conditions, small quantity generator
- Small (high end) landfill size, median climatic conditions, small quantity generator

Exposure Pathways and Receptors Considered

Contaminants were assumed to escape from the landfill via a subsurface or air pathway. Within the landfill, however, the contaminants were assumed to partition differently to the air and water based on chemical-specific characteristics. The partioning model incorporated first order degradation (e.g., degradation calculated from a "half-life"). The results of this partioning were used as inputs to the subsequent air and ground water transport models. Risks associated with the following exposure pathways were considered for each constituent:

- inhalation
- ground water ingestion
- indirect inhalation exposure of groundwater in the shower, bathroom, and whole house, and
- indirect dermal exposure of groundwater.

In the air pathway, the released contaminant is assumed to transport through the air to an offsite receptor. Contaminant is diluted by transport, and removed prior to reaching the receptor by deposition. The receptor becomes exposed via inhalation of the contaminant.

In the ground water pathway, the contaminant is assumed to reach an offsite drinking water well. The receptor becomes exposed by drinking the water. Other exposure pathways considered result from household uses of water (e.g., showering). Routes of exposure from these pathways include dermal and inhalation exposure.

All of the pathways consider two receptors: farmer and child. Appropriate intake assumptions for each receptor were obtained from EPA's 1997 Exposure Factors Handbook. Health benchmarks include reference doses (RfDs) and cancer slope factors (CSFs) for estimating risk from ingestion and dermal exposures; risk from inhalation were determined using reference concentrations (RfCs) and inhalation CSFs. Benchmarks were principally obtained from EPA's Integrated Risk Information System (IRIS), supplemented with other sources as appropriate. Most of the compounds had oral benchmarks while a significant number did not have inhalation benchmarks.

Inhalation risk factors are estimated for a child in Houston exposed for 12 hours to constituents disposed of by a LQG in a small landfill 75 meters away. Ground water ingestion risk factors are estimated for a child in Houston ingesting ground water from a well located 102 meters from a small landfill containing constituents disposed of by a LQG. Indirect exposure factors are determined by adding the HQs for inhalation of the constituent in the shower, bathroom, and whole house. These HQs are calculated using a unit concentration for the constituent's concentration in ground water. Finally, the HQ calculations for dermal exposure were also based on the constituent's concentration in ground water.

Separate risks were calculated for each of the eight landfill management scenarios discussed above. For each scenario, risks were determined for the direct inhalation of the landfill vapors, ingestion of contaminated drinking water, and indirect exposure from household use of water. Both adult and child receptors were considered in the risk screening. The highest risks calculated in this manner were used in subsequent calculations.

The risks calculated from this assessment are linear, allowing for easier manipulation and calculations, performed in the following subsections.

1.3.2 Number of Facilities Resulting in Risk at Landfill

Table 1-3 shows that the quantity of methyl ethyl ketone in a landfill that would result in unacceptable risks is 0.33 kg/day. To estimate the number of facilities that contribute to this amount, the following factors were considered:

- The results of Section 1.3.1 ('critical' quantity of contaminant resulting in HQ=1)
- The quantity of solvent that is likely to be present on the rag (accounts for solvent removal technologies and low or high use activities)
- The percentage of rags generated that actually enter the solid waste stream (e.g., not laundered)
- The percentage of rags in the solid waste stream that actually enter a landfill (e.g., not combusted)
- The number of rags generated by an individual facility for offsite management
- The percentage of contaminant likely to be present in a solvent.

A sample calculation for methyl ethyl ketone is given in Attachment A. The starting point for this calculation is the loading rate resulting from Section 1.3.1. Next, the quantity of solvent used by a facility is accounted for. A facility can use a small number of rags or a large number (e.g., 30 to 120 rags, 40 grams apiece). The rag can have varying amounts of solvent present (e.g., 10 to 100 percent of the rag weight is solvent). Both of these values are present in the dominator such that the total quantity of solvent disposed by a single facility is 0.12 to 4.8 kg/facility/day . Finally, the percentages of facilities likely to use disposable rags (as opposed to reusable rags) and use landfill management (rather than combustion management) are also given in the denominator; the effect of such factors is to increase the number of facilities that it would take to cause unacceptable risks from landfilling. The result of these calculations show that 1.3 to 170 facilities (per landfill) could use methyl ethyl ketone. Note that these represent the number of facilities served by a single landfill, regardless of whether they dispose rags in the landfill.

The quantity of solvent in a rag can range from a ratio of almost 7:1 (solvent to rag) to less than 0.5:1. Additionally, solvent removal technologies (in particular centrifuging) can remove up to 90 percent of the solvent. Conclusions from this investigation were as follows: (1) within a facility or industry, different tasks require different quantities of solvent; (2) the ratios for facilities within the printing industry were generally higher than the ratios from other facilities, such as those in the auto body industry. For this assessment, the quantity of solvent on the disposed rag was assumed to be 1:1, with an option that 90 percent of the constituent would be removed by centrifuge.

To estimate the quantity of solvent added to the wipe or rag, the wipes and rags prior to use were first characterized. There are three types of wipes, towels and rags used in conjunction with solvents: disposable paper wipes and rags, disposable cloth wipes and rags, and reusable (launderable) cloth towels. EPA obtained samples of each of these three materials, representing the leading brands. Typical or average weights found during this investigation were as follows:

2.8 grams for paper wipes and rags, 10.4 grams for disposable cloth wipes and rags, and 25 grams for launderable towels. As expected, manufacturers produce these wipes, towels and rags in a variety of sizes and weights, which provides some variability to these results. The mass used in this assessment was 40 grams per rag, representing the typical weight of an unused rag (SAIC, Use and Management Practices of Solvent Contaminated Industrial Shop Towels, Final Report, 1997; solvent ratios on page 17; removal efficiencies on page 24; rag weight on page 25). Finally, a regulatory option is being considered for generators of 5 grams or less of solvent (EPA, "A Reorientation Discussion Paper on Solvent-Contaminated Shop Towels and Wipes," April 28, 1999). For these reasons, the estimated quantity of solvent on a rag ranged from 4 to 40 grams in the calculations, for a 40 gram rag.

The percentage of rags generated that actually enter the solid waste stream (e.g., not laundered) was assumed to be 23 percent. This is equal to the number of disposable rags used with RCRA solvents each year (166 million) divided by the sum of reusable and disposable rags used with RCRA solvents each year (560 million are laundered). Data are from SAIC, Technical Background Document for Proposed Rule Affecting Solvent-Contaminated Shop Towels, Wipes, and Rags," draft May 25, 1999, pages 22 and 28.

The number of disposable rags that are actually managed in a landfill was assumed to be 78 percent. This is equal to the quantity of municipal solid waste landfilled (118 million tons in 1995) divided by the quantity of municipal solid waste discarded (152 million tons in 1995). The difference is the quantity combusted. Data are from EPA's Municipal Solid Waste Factbook, 1997, Internet version.

The number of rags generated by an individual facility for offsite management varies based on the type of business, and the facility size (e.g., LQG or SQG). The range used in the calculations was 30 to 120 rags per day. This data is from SAIC, "Technical Background Document for Proposed Rule Affecting Solvent-Contaminated Shop Towels, Wipes, and Rags," draft May 25, 1999, page 24. The quantities of wipes and rags used varies from facility to facility, which is partially accounted for by considering ranges in the quantity of wipes used. During the site visits, EPA found the number of wipes and rags used varied from 40 to 2,000 per month. These estimates were consistent with the overall range found from a survey conducted by the printing industry. EPA estimated that a "typical" SQG facility would use 30 wipes or rags per day (about 600 per month) and a "typical" LQG, would use 120 wipes or rags/day (about 2,400 per month). These quantities were estimated from factors such as the accumulation time and quantity permissible in the federal regulations. Both of these calculated estimates are consistent with the usage data determined from the survey results and the site visits.

The percentage of contaminant likely to be present in a solvent has high uncertainty. A solvent can contain contaminant concentrations ranging from less than 1 to 100 percent. Data characterizing solvent composition in three sectors (printing, furniture, and autobody repair) were prepared as an addendum to SAIC, "Use and Management Practices of Solvent Contaminated Industrial Shop Towels," Final Report, 1997. A total of 15 different F-listed constituents were found in the solvents identified. For each constituent in each industry, a range was developed. For constituents with no data, an arbitrary range of 5 to 50 percent was used which corresponded, approximately, to the range for most constituents with composition data. The arbitrary percentage range is uncertain because the data are not representative of the evaluated industries.

Table 1-4 summarizes the values of the parameters described in this section.

Table 1-4. Parameters Used to Estimate Number of Facilities Resulting in Risk		
Parameter	**Value**	**Source**
Unit risk for each constituent	Constituent-dependent	March 1999 RTI Report
Quantity of solvent on rag	10 - 100 %, 40 g rag	1997 SAIC Use and Management Report
Percent of generators using disposables	23 %	1999 SAIC Technical Background Document
Percent of disposables ultimately managed in landfills	78 %	1997 EPA MSW Factbook
Quantity of rags used by a facility	30 to 120	SAIC Technical Background Document
Percentage of constituent in solvent	Constituent-specific	Assumed, and SAIC Use and Management Report, 1997

1.3.3 Universe of Facilities

The results of Section 1.3.2 show the number of facilities which, when using solvents with rags, are likely to result in excess risk. This number must be compared with data derived from the universe of generators to assess if this is likely to be of concern. This section develops the number of facilities representing the potential universe for each contaminant. The following factors were considered in deriving this number:

- The estimated number of facilities using solvent-contaminated rags.
- The likelihood that a facility would use an F-listed solvent.
- The likelihood that the F-listed solvent would contain the subject contaminant.
- The number of facilities served by a landfill

The values used in calculations, and the source of those estimates, are described below. A sample calculation for methyl ethyl ketone is given in Attachment A. The result is that the number of facilities likely to use methyl ethyl ketone ranges from 1.7 to 19, on a per landfill basis. This range should be compared to the results of Section 1.3.2, where excess risk from landfill disposal would result from between 1.3 and 170 facilities. Because the range overlaps, further attention is warranted. If only the upper end of each range were evaluated (i.e., 19 versus 305), this would indicate that methyl ethyl ketone would not be of concern.

The estimated number of LQGs and SQGs using solvent-contaminated rags is provided in EPA, "A Reorientation Discussion Paper on Solvent-Contaminated Shop Towels and Wipes," April 28, 1999. The sum total of 77,700 facilities is comprised of 71,400 SQGs and 6,300

LQGs. To minimize complexity, distinctions between solvent use by individual sectors were not made.

The likelihood that a facility would use an F-listed solvent was estimated to be 11 percent. The 11 percent was determined in the following manner. Ten percent of the solvents used in the printing industry were nonhazardous when spent, 80 percent were characteristically hazardous when spent, and 10 percent were listed hazardous wastes (e.g., F-listed) when spent. The estimated number of facilities in the previous paragraph only considered RCRA facilities (i.e., those managing either listed or characteristic wastes, which would only account for 90 percent of the industry), so the percentage of facilities managing F-listed solvents was assumed to be 0.1/0.9, or 11 percent. The source of these data is SAIC, "Technical Background Document for Proposed Rule Affecting Solvent-Contaminated Shop Towels, Wipes, and Rags," draft May 25, 1999, page 21.

The likelihood that the F-listed solvent would contain the subject contaminant could not be estimated with certainty because representative data are not available. Each constituent was assigned a value of 10 percent or 50 percent (i.e., if a facility uses an F-solvent, then this is the probability that the subject contaminant would be present). These numbers were arbitrarily selected. The following approach was used in assigning a value of 10 percent or 50 percent to each constituent:

- Data characterizing solvent composition in three sectors (printing, furniture, autobody repair were prepared as an addendum to SAIC, "Use and Management Practices of Solvent Contaminated Industrial Shop Towels," Final Report, 1997. A total of 15 different F-listed constituents were found in the solvents identified. Each of these constituents were assigned a value of 50 percent since their use in solvents is documented.

- All but three constituents were shown to have relatively high risk in the March 1999 RTI report (i.e., the highest unit risk are two orders of magnitude below the HQ and carcinogenic risk thresholds). It was assumed that most facilities would not use such solvents, if their use was not documented in the 1997 SAIC report. Each of these constituents were assigned a value of 10 percent

- The remaining three compounds considered to be less toxic (i.e., the highest unit risk are two orders of magnitude below the HQ and carcinogenic risk thresholds) were assigned a probability of 50 percent. It was assumed that facilities would use these less toxic components preferentially over more toxic components. These three compounds are 1,1,2-trichlorotrifluoroethane, m-xylene, and o-xylene.

Finally, the results of these calculations must be converted to a landfill basis, because the number of facilities derived in Section 1.3.2 are on a landfill basis. A national average was not conducted because it would not account for variations on the local level. The distribution of landfills by state is available from BioCycle or EPA sources. The distribution of likely rags generators by state, and the distribution of landfills by state, was estimated or known from SAIC's "Facility Distribution" memo to Jim O'Leary, July 3, 1998. Data for Connecticut show that 1.3% of the nation's rags generators are likely located in this state, which has 3 landfills. The ratio of generators to landfills (1.3%/3 or 0.46 percent) is the highest of any state. The national average is 0.04% (100%/2514 landfills). These two values were selected as the low and high values in calculations. Numbers below the median were not used because very low numbers are actually obtained, which can skew the analysis.

Table 1-3 summarizes the values of the parameters described in this section.

Table 1-3. Parameters Used to Estimate Universe of Facilities Using a Solvent Component

Parameter	Value	Source
Total number of facilities	77,700	April 1999 EPA Briefing
Percent of facilities using F-listed solvent	11 %	1999 SAIC Technical Background Document
Percent of facilities using solvent with subject constituent	10 to 50 %	Assumed, and 1997 SAIC Use and Management Report
Percent of facilities served by a single landfill	0.04 to 0.43 %	1998 SAIC Memo

1.4 Centrifuging

Results using different assumptions than those presented above are easy to assess. For example, the previous analysis assumed that a facility disposes between 0.12 and 4.8 kg/d solvent. An analysis can be conducted where a facility generates a much higher quantity of solvent-contaminated rags (i.e., 10 kg/d of solvent), but incorporates centrifuging so that it actually disposes 1 kg/day (or 10 percent of the starting quantity). The assumption of 10 kg of solvent per day corresponds to the generation of 500 solvent-contaminated rags, each weighing 20 grams each, and loaded with an equal weight of solvent.

For this set of assumptions, the lower bound of the number of facilities that result in excess risk increases by a factor of 5. In other words, the centrifuging assumption results in less risk than an assumption where centrifuging is not used, even when higher initial solvent use is employed. For six constituents (acetone, carbon disulfide, p-cresol, tetrachloroethylene, toluene, and carbon tetrachloride), multiplying the lower bound of column 3 by a factor of 4.8 results in higher values than presented in column 4. In conclusion, using the centrifuge assumption results in six less constituents of concern (i.e., 25 of 34 constituents fall below the risk criteria; in the initial assessment 19 of 34 constituents fell below risk criteria).

Attachment A. Sample Calculations for Methyl Ethyl Ketone

For Section 1.3.1

Inhalation risk: HQ = 0.00003	(From RTI, 1999)
Groundwater ingestion risk: HQ = 0.1	(From RTI, 1999)
Indirect risk (inhalation) HQ = 4	(From RTI, 1999)
Indirect risk (dermal) HQ = 0.0007	(From RTI, 1999)

Maximum risk (HQ) = 4

$$\text{Quantity of MEK causing risk} = \frac{1.3kg}{d \cdot landfill} \times \frac{1}{4} = 0.33 \;{}^{kgMEK}\!/_{d \cdot landfill}$$

For Section 1.3.2

Quantity of MEK causing risk = 0.33 $^{kgMEK}/_{d \cdot landfill}$

Quality of solvent on rag = $\frac{40g\ rag}{4-40g\ solvent}$ (Assumption-from SAIC 1997)

% generators using disposables = 23 % (From SAIC 1999)

% disposable in landfills = 78 % (From EPA 1997)

Quantity of rags used by facility = 30 to 120 rags x 40 g/rag = 1.2 to 4.8 kg rags (From SAIC 1999)

% of MEK in solvent = 9 to 30% (From SAIC 1997)

$$0.33\ \frac{kg\ MEK}{day \cdot landfill} \times \frac{kg\ solvent}{0.09 \text{ to } 0.30 \text{ kg } MEK} \times \frac{40g\ rag}{4-40g\ solvent} \times \frac{1}{0.23} \times \frac{1}{0.78} \times \frac{day - facility}{1.2\ to\ 4.8kg\ rag}$$

$$= 1.3 \text{ to } 170\ {}^{facility}\!/_{landfill}$$

For Section 1.3.3

Total number of RCRA LQG + SQGs using F-or D-solvent: 77,700 (EPA, 1999)

Percent using F-list solvent $\dfrac{10\% \; (\#\; using F-solvent)}{10\% + 80\% \; (\#\; using\; F-or\; D-solvent)} = 11\%$ (SAIC, 1999)

Percent of facility using MEK 50% (Indicating it is used, based on site visits to some facilities)

Percent of facilities served by landfills :

High is Connecticut: $\dfrac{5{,}794}{446{,}000} = 1.3\% = \dfrac{SIC code\; 27,55,75\; in\; \text{CT}}{total\; \text{SIC code } 27,55,75\; in\; \text{US}}$

$$\frac{1.3\%}{3} = 0.43\,\%\!/\!landfill$$

Medium in US- $\dfrac{100\%}{2{,}514\; lf} = 0.040\,\%\!/\!landfill$

$$77{,}700 \times 0.11 \times 0.50 \times [0.04\% \;to\; 0.43\%] = 1.7 \;to\; 19\; \frac{facilities}{landfill}$$

Attachment B. Risk Assessment Results and Solvent Composition

Calculation of Risks Based on March 31, 1999 RTI Report
Indirect exposure factors from Table 6-19
Inhalation Risk Factors from Table 6-7: small LF, LQG, Houston, 12-hr., Child
GW ingestion data from Table 6-15: nationwide distribution of wells, no liner, small LF, LQG, Houston, 12-hr Ingestion, Child
GW concentration data from Table 6-20

Limitations: (1) all indirect inhalation risks are summed; (2) indirect inhalation and ground water risks are not summed.

Constituent	Inhalation Risk Factor	GW Ingestion Risk Factor	GW Concent-ration (mg/L)	Indirect Exposure Factor		Indirect Risk	Maximum Risk	Assumption 1	Assumption 2: Low End Value	Assumption 2: High End Value	Assumption 3: Low End Value	Assumption 3: High End Value
				Sum	Dermal			Solvent quantity (kg/d)	# Facilities for HQ =1 or Risk = 10^6	# Facilities for HQ =1 or Risk = 10^6	# Potential Facilties Using Solvent	# Potential Facilties Using Solvent
Pyridine	0.0003	90	2E+00	60	0.39	1.20E+02	120	0.01	0.0	10.1	0.3	3.7
Nitrobenzene	0.00013	5	5E-02	500	3.9	2.50E+01	25	0.05	0.1	48.3	0.3	3.7
p-Cresol	NA	3	2E-01	NA	0.82	1.64E-01	3	0.43	1.0	402.6	0.3	3.7
Acetone	0.000002	0.7	1E+00	0.05	0.001	5.00E-02	0.7	1.86	5.3	1,725.3	1.7	18.5
Butanol	NA	0.8	1E+00	NA	0.0054	5.40E-03	0.8	1.63	47.2	1,887.1	1.7	18.5
Methyl isobutyl ketone	0.0002	0.6	7E-01	60	0.0098	4.20E+01	42	0.03	0.1	28.8	0.3	3.7
Isobutyl alcohol	NA	0.3	1E+00	NA	0.0015	1.50E-03	0.3	4.33	100.6	4,025.8	1.7	18.5
2-Ethoxyethanol	0.000008	0.3	2E+00	0.02	0.00026	4.00E-02	0.3	4.33	10.1	4,025.8	0.3	3.7
Ethyl ether	NA	0.3	8E-01	NA	0.0026	2.08E-03	0.3	4.33	100.6	4,025.8	0.3	3.7
Methanol	0.000002	0.2	2E+00	0.01	0.00011	2.00E-02	0.2	6.50	22.9	30,193.2	1.7	18.5
m-Cresol	NA	0.2	2E-01	NA	0.085	1.70E-02	0.2	6.50	15.1	6,038.6	0.3	3.7
Methyl ethyl ketone	0.00003	0.1	2E+00	2	0.00036	4.00E+00	4	0.33	1.3	167.7	1.7	18.5
o-Cresol	NA	0.1	1E-01	NA	0.088	8.80E-03	0.1	13.00	30.2	12,077.3	0.3	3.7
Ethyl acetate	NA	0.08	1E+00	NA	0.00042	4.20E-04	0.08	16.25	94.4	18,870.8	1.7	18.5
Carbon disulfide	0.00007	0.08	1E-01	20	0.035	2.00E+00	2	0.65	1.5	603.9	0.3	3.7
Tetrachloroethylene	0.0001	0.02	5E-03	40	0.56	2.00E-01	0.2	6.50	16.8	15,096.6	1.7	18.5
Chlorobenzene	0.0004	0.02	6E-03	600	0.55	3.60E+00	3.6	0.36	0.8	335.5	0.3	3.7
Cyclohexanone	NA	0.02	1E+00	NA	0.00014	1.40E-04	0.02	65.00	1,887.1	75,483.1	1.7	18.5
Ethyl benzene	0.000009	0.007	1E-02	10	0.18	1.00E-01	0.1	13.00	754.8	60,386.5	1.7	18.5
Toluene	0.00005	0.006	2E-02	30	0.053	6.00E-01	0.6	2.17	4.9	3,354.8	1.7	18.5
Dichlorodifluoromethane	0.0002	0.003	1E-02	60	0.017	6.00E-01	0.6	2.17	5.0	2,012.9	0.3	3.7
1,1,1-Trichloroethane	0.00004	0.002	8E-03	10	0.026	8.00E-02	0.08	16.25	25.2	3,594.4	1.7	18.5
Trichlorofluoromethane	0.00007	0.0009	5E-03	16	0.018	8.00E-02	0.08	16.25	89.9	4,717.7	1.7	18.5
1,2-Dichlorobenzene	0.000002	0.0008	2E-03	50	0.24	1.00E-01	0.1	13.00	30.2	12,077.3	0.3	3.7
o-Xylene	NA	0.0005	1E-02	NA	0.009	9.00E-05	0.0005	2,600.00	6,038.6	2,415,458.9	1.7	18.5
m-Xylene	NA	0.0005	1E-02	NA	0.01	1.00E-04	0.0005	2,600.00	267,196.8	10,687,871.4	1.7	18.5
Xylenes (total)	0.00001	0.0002	7E-03	30	0.0096	2.10E-01	0.21	6.19	42.3	28,755.5	1.7	18.5
1,1,2-Trichlorotrifluoroethane	0.000002	0.00002	8E-03	0.4	0.00036	3.20E-03	0.0032	406.25	943.5	377,415.5	1.7	18.5
2-Nitropropane © - air)	9.2E-06	NA	4E-01	1.0E-02	NA	4.00E-03	4000.00	0.00	0.0	0.3	0.3	3.7
Methylene chloride (C)	3.8E-09	1.5E-05	3E-01	7.00E-06	8.90E-07	2.10E-06	15.00	0.09	0.1	44.7	1.7	18.5
Benzene (C)	5.1E-08	1.3E-05	7E-02	1.00E-04	1.50E-05	7.00E-06	13.00	0.10	0.2	92.9	0.3	3.7
1,1,2-Trichloroethane (C)	3.0E-08	7.0E-06	2E-02	2.00E-04	1.80E-05	4.00E-06	7.00	0.19	0.4	172.5	0.3	3.7
Carbon tetrachloride (C)	9.4E-08	2.6E-06	4E-03	2.00E-04	1.10E-04	8.00E-07	2.60	0.50	1.2	464.5	0.3	3.7
Trichloroethylene (C)	6.5E-09	2.7E-07	5E-03	3.00E-05	1.00E-05	1.50E-07	0.27	4.81	11.2	4,473.1	0.3	3.7

"Maximum risk" is HQ for non-carcinogens and one million times risk for carcinogens.
(C) indicates contaminant is carcinogenic by both inhalation and ingestion pathways; © - air) indicates contaminant is carcinogenic only by inhalation pathway.
The baseline assumption for above data: 1 LQG per landfill, 1.3 kg solvent/generator/day
Assumption 1: Quantity of solvent in landfill is equal to HQ = 1 or Risk = 10^{-6} (1.3 kg/d/Maximum Risk)
Assumption 2: # Facilities that can dispose solvent containing each constituent. Incorporates % facilities using disposables (23), % of MSW that is landfilled (78%), centrifuge/use assumption (10-100% solvent on rag), quantity of rags/facility (1.2-4.8 kg/facility), % of constituent in solvent (5-50% default), or data on solvent compositions.
Assumption 3: # Facilities in each sector that are served by a single landfill. Incorporates # of facility in universe, % using F-list solvents (11%), % likely to use particular compound (high: 50%, L: 10%) based on solvent use profile, and distribution of landfills in CT (1.3%/3) or US (100%/2514).

Percentage of Constituents Present in Solvents
(Based on MSDSs from 1997 SAIC Use and Management Report)

Constituent	Printing Industry		Furniture Industry		Auto Body Repair Industry	
	Low	High	Low	High	Low	High
Pyridine						
Nitrobenzene						
p-Cresol						
Acetone	25	41	5	36.96	15	20
Butanol			4	4		
Methyl isobutyl ketone						
Isobutyl alcohol			5	5		
2-Ethoxyethanol						
Ethyl ether						
Methanol	12	30	0.11	33		
m-Cresol						
Methyl ethyl ketone	9	18	20	30		
o-Cresol						
Ethyl acetate	10	20	4	4		
Carbon disulfide						
Tetrachloroethylene	2	45				
Chlorobenzene						
Cyclohexanone			4	4		
Ethyl benzene	1	2				
Toluene	10	32	3	51	10	50
Dichlorodifluoromethane						
1,1,1-Trichloroethane	21	75				
Trichlorofluoromethane	16	21				
1,2-Dichlorobenzene						
o-Xylene						
m-Xylene			1.13			
Xylenes (total)	1	17	0.28	8		
1,1,2-Trichlorotrifluoroethane						
2-Nitropropane © - air)						
Methylene chloride (C)			11	92.5	9	9
Benzene (C)						
1,1,2-Trichloroethane (C)						
Carbon tetrachloride (C)						
Trichloroethylene (C)						